

Material for the ASM Evening Program Talk.

Title: Weather on Mars, The view from the Mars Pathfinder Lander.

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Although it is composed primarily of CO₂, with a surface pressure of about 7 mbar, the atmosphere of Mars has many similarities with that of the Earth. It is driven primarily by solar heating at the surface, and the Mars rotation period of 24 hrs 40 minutes and axis inclination of 25.2° produce daily cycles, seasonal variations and circulation patterns that have recognizable terrestrial analogs. On the other hand, the relatively eccentric orbit means that the solar constant varies by as much as 45% at Mars, peaking in the southern summer, so that the seasons are asymmetrical in the two hemispheres. During the polar nights, the surface becomes cold enough for atmospheric CO₂ to condense on to seasonal polar caps, causing seasonal surface pressure variations of 30%. Finally, water vapor, though present in the martian atmosphere, plays only a minor role in atmospheric thermodynamics. Its place is taken by the ubiquitous dust which, once raised, enhances solar heating of the atmosphere, producing local storms that raise more dust. In the southern summer this process can run away, creating global dust storms that envelop the entire planet.

Much of our knowledge of the martian atmosphere comes from the Viking orbiter and lander missions more than 20 years ago. When Pathfinder landed at 3 am local solar time (LST) on 4th July 1997, the Atmospheric Structure Investigation / Meteorology (ASI/MET) experiment made in situ measurements of vertical atmospheric structure during entry, and of surface pressure, temperature and wind velocity variations over the 83 days of the landed mission. The Imager for Mars Pathfinder (IMP), also monitored atmospheric dust opacity at several wavelengths, measured the water vapor column, and obtained dramatic images of sunrises, sunsets, and clouds. In addition to providing valuable new atmospheric data, these measurements, when compared with those taken by Viking, allow martian climate variations in the mid to late northern summer season to be studied.

Below 60 km the vertical atmospheric temperature structure derived from ASI/MET measurements is similar to that recorded by the Viking Lander 1 (VL-1), although a temperature inversion at 10 km may mark the level of the water ice clouds seen by the IMP. Above 60 km, the Pathfinder profile is on average 20 K cooler than VL-1, due primarily to time of day effects. At 80 km, the temperature dips below the saturation temperature of CO₂, and it is possible that CO₂ ice clouds may form. The surface, pressure, temperature and wind record is broadly similar to that returned by VL-1 for the same season at a similar latitude. A minimum in daily mean pressure occurs within a few days of the annual minimum seen by VL-1, and there are signs that synoptic variability is increasing as expected towards the end of the data set. The amplitude of the semi-diurnal pressure tide suggests that dust is well distributed globally and vertically, which is consistent with the IMP measurements of surface visibility and dust column opacities of 0.5. Surface temperature variations are dominated by a 65 K amplitude daily cycle and day-to-day variations are relatively small. Pathfinder temperatures are 10-13 K warmer than those seen by VL-1, both day and night, because

of the lower albedo and larger thermal inertia of the surface. Short term temperature fluctuations of 15-20 K, produced by surface heating and turbulent mixing, are seen during the day. Surface winds rotate clockwise through the compass points during the day, like VL-1, but appear to be controlled by local slopes. Winds blow from the south for most of the night, down the Ares Vallis canyon system and are often correlated with positive excursions from the nighttime cooling curve, as the stably stratified surface layer is disturbed. Generally speeds never exceed 5-10 m/s and are often less than 1 m/s. Dust devils pass almost daily over or near the Pathfinder landing site. Their signature is clearly revealed in short lived pressure minima with correlated wind and temperature variations. Dust devils may be an important source of atmospheric dust at this season. IMP images reveal spectacular water ice clouds before sunrise on many days. These clouds are seen to move, but their precise altitude and speed are uncertain. Less well defined dust clouds are seen after sunset. Direct observations of the sun at several wavelengths, show that atmospheric opacity is high in the morning and falls as the day progresses and water ice particles evaporate. Noon time opacities are remarkably constant, rising slowly from 0.45 to 0.60 over the 83 days of the landed mission.